Contents of Reply

(1) Examiner's opinion

According to International Search Report and written opinion of International Searching Authority sent on October 26, 2004, the Examiner is of an opinion that the inventions of claims 1 to 3, 7 to 12, and 16 to 19 do not have novelty or inventive steps over Japanese Laid-Open Patent Application Publication No. 2002-9290 (cited prior art 1), Japanese Laid-Open Patent Application Publication No. Hei. 9 – 116163 (cited prior art 2), and Japanese Laid-Open Patent Application Publication No. Hei. 10 – 190001 (cited prior art 3).

Accordingly, the applicant amended claims to make clear distinction between the inventions of the subject application and the invention of the above identified cited prior arts in contents of amendments submitted along with the contents of reply. Below, the applicant argues the inventions defined in amended claims.

(2) Grounds for amendments

Claim 1 and Claim 10 have been amended to include "a molecular axis of main chains thereof is oriented to be oblique with respect to a direction of electric field in a channel formed in the semiconductor layer."

This amendment is supported by page 25 line 5 to page 27 line 6 in description and Fig. 6A to 6C, page 27 line 6 to page 28 line 6 in description and Fig. 7, and page 34 line 8 to page 35 line 18 in description and Figs. 10A and 10B, and therefore does not add new matter.

(3) Novelty and inventive step

3 –1 Description of the inventions of the subject application

Hereinbelow, the inventions defined in amended claims 1 and 10 (independent claims) will be described.

A thin film transistor defined in amended claim 1 comprises a semiconductor layer; and a source region and a drain region provided to be isolated from each other so as to mutually oppose the semiconductor layer, wherein the semiconductor layer has π-conjugated organic semiconductor molecules as its main component; and the π-conjugated organic semiconductor molecules are oriented so that π orbitals thereof substantially oppose each other and that a molecular axis of main chains thereof is oriented to be oblique with respect to a direction of electric field in a channel formed in the semiconductor layer.

A method of fabricating a thin film transistor defined in amended claim 10, having a semiconductor layer, and a source region and a drain region provided to be isolated from each other so as to mutually oppose the semiconductor layer, comprises using π-conjugated organic semiconductor molecules for the semiconductor layer as its main component; and orienting the π-conjugated organic semiconductor molecules so that π orbitals substantially oppose each other, and that a molecular axis of main chains thereof is oriented to be oblique with respect to a direction of electric field in a channel formed in the semiconductor layer.

3 – 2 Description of cited prior art

Cited prior art 1 discloses a field effect transistor in which an organic semiconductor film is formed of organic molecules having planar unsaturated ring or planar organic molecules, such as tiophene, pentacene, or anthracene, and at least one of the planar organic molecules or planar portions of the

organic molecules are oriented on a substrate to form an angle of 45 degrees or larger, preferably 75 degrees or larger with respect to a substrate surface, and a method of fabricating the field effect transistor.

Cited prior art 2 discloses a field effect transistor in which plural fiber tissues (or structures) made of conductive polymer such as polymer or oligomer including one or more of monomers, for example tiophene and the like and their derivatives, and growing in a direction along a substrate surface gather to form an active layer, and main chains of the respective fiber tissues are oriented in a direction perpendicular to a straight line connecting a source electrode and a drain electrode to each other, and a method of fabricating the field effect transistor.

Cited prior art 3 discloses using as a semiconductor layer of a thin film transistor, derivative of tiophene in which π orbitals do not extend from π-conjugated organic semiconductor molecules in the same vector direction.

3 – 3 Comparison between the invention of the subject application and the invention of cited prior arts

3 – 3 – 1 Comparison between the invention of amended claim 1 and the invention of the cited prior arts

Amended claim 1 recites features "the π-conjugated organic semiconductor molecules are oriented so that π orbitals thereof substantially oppose each other and that a molecular axis of main chains thereof is oriented to be oblique with respect to a direction of electric field in a channel formed in the semiconductor layer."

According to such features, since the π-conjugated organic semiconductor molecules are oriented so that π orbitals thereof substantially

oppose each other and that a molecular axis of main chains thereof is oriented to be oblique with respect to a direction of electric field in a channel formed in the semiconductor layer, charge transfer between adjacent π-conjugated organic semiconductor molecules utilizing overlapping of π orbitals and charge transfer in π-conjugated organic semiconductor molecules along a molecular axis of main chain are each effectively used in a direction from a source region to a drain region to which electric field is applied. In contrast to a case where only charge transfer utilizing overlapping of the π orbitals is used, or charge transfer along the molecular axis of main chain and hopping of electrons between molecules is used, a thin film transistor is suitably able to have higher carrier mobility.

In other words, the invention of amended claim 1 is such that the charge transfer from the source region to the drain region is accomplished by using, two charge transfer paths, namely, a first charge transfer path along the molecular axis of main chain and a second charge transfer path utilizing overlapping of the π orbitals, and the carrier mobility of the thin film transistor is effectively improved by utilizing synergetic effect resulting from the use of these two transfer paths.

In contrast, the cited prior art 1 only discloses that, in the organic semiconductor film, at least one of the planar organic molecules or the planar portions of the organic molecules are oriented on a substrate to form an angle of 45 degrees or larger with respect to the substrate surface, and does not disclose or suggest that "a molecular axis of main chains of the π-conjugated organic semiconductor molecules is oriented to be oblique with respect to a direction of electric field in a channel formed in the semiconductor layer.",

namely, a molecular axis of main chains of the organic molecules is oriented to be oblique with respect to a direction of electric field in a channel formed in the semiconductor layer. That is, the invention of amended claim 1 defines both of the orientation of the π orbitals and orientation of the molecular axis of the main chain, but the invention of the cited prior art 1 only defines the orientation of the π orbitals. Therefore, in the structure of the organic semiconductor film of the field effect transistor disclosed in the cited prior art 1, the charge transfer path utilizing overlapping of the π orbitals is able to be utilized but the two charge transfer paths including the charge transfer path along the molecular axis of the main chain of the organic molecules and the charge transfer path utilizing overlapping of the π orbitals are unable to be used for the charge transfer from the source electrode to the drain electrode. For this reason, according to the structure of the organic semiconductor film disclosed in the cited prior art 1, the carrier mobility of the field effect transistor is unable to be effectively improved.

The cited prior art 2 only discloses main chains of the respective fiber tissues are oriented in a direction perpendicular to a straight line connecting a source electrode and a drain electrode to each other, and does not disclose or suggest that the main chains of the respective fiber tissues are oriented to be oblique with respect to electric field in channel formed in the active layer. The terms "oriented to be oblique with respect to the direction of electric field" means "oriented to be neither perpendicular nor parallel to a reference direction" according to fifth edition of Kojien of Iwanami Shyoten (published on November 11, 1998). So, in the thin film transistor of amended claim 1 is structured in such a manner that, in the semiconductor layer, the molecular

axis of the main chain of the π-conjugated organic semiconductor molecules is oriented to be neither perpendicular nor parallel with respect to the direction of the electric field in the channel formed in the semiconductor layer. In contrast, according to the cited prior art 2, the main chains of the respective fiber tissues are oriented to be perpendicular to the straight line (reference direction, corresponding to the direction of the electric field in the channel) connecting the source electrode and the drain electrode to each other. In this respect, therefore, there is a significant distinction between the invention of amended claim 1 and the invention of the cited prior art 2. According to the structure of the active layer of the field effect transistor disclosed in the cited prior art 2, the charge transfer utilizing the π orbitals is achieved but both the charge transfer along the main chains of the respective fiber tissues and the charge transfer utilizing overlapping of the π orbitals are not achieved to be utilized for the charge transfer from the source electrode to the drain electrode. For this reason, the carrier mobility of the field effect transistor is unable to be effectively improved with the structure of the active layer disclosed in the cited prior art 2.

The cited prior art 3 is associated with the invention of claim 8. So, the cited prior art 3 does not disclose or suggest that a molecular axis of main chains of the π-conjugated organic semiconductor molecules is oriented to be oblique with respect to a direction of electric field in a channel formed in the semiconductor layer.

As should be understood from the above, the cited prior arts do not disclose or suggest the invention of amended claim 1, and therefore, amended claim 1 is believed to have novelty and inventive step over the cited prior arts

1 to 3.

3 – 3 – 2 Comparison between the invention of amended claim 10 and the invention of the cited prior arts

The invention defined in amended claim 10 relates to a method of fabricating a thin film transistor to embody the invention defined in amended claim 1. Since the invention defined in amended claim 1 is not disclosed or suggested in the cited prior arts 1 to 3, the invention defined in amended claim 10 is not disclosed or suggested in the cited prior arts 1 to 3. So, the invention defined in amended claim 10 is believed to have novelty and inventive step over the cited prior arts 1 to 3.

3 – 3 – 3 Comparison between the invention of other claims and the invention of the cited prior arts

Claims 2, 3, 7 to 9, 11, 12, and 16 directly or indirectly depend from claim 1 or claim 10. Since the inventions defined in claims 1 and 10 are believed to have novelty and inventive step over the cited prior arts 1 to 3, the inventions defined in claims 2, 3, 7 to 9, 11, 12, and 16 are believed to have novelty and inventive step over the cited prior arts 1 to 3.

The inventions defined in claims 17 to 19 are an active matrix-type display, a wireless ID tag, and a portable device, comprising the thin film transistor as recited in any one of claims 1 to 9. Since the inventions defined in claims 1 to 9 are believed to have novelty and inventive step over the cited prior arts 1 to 3, the inventions defined in claims 17 to 19 are believed to have novelty and inventive step over the cited prior arts 1 to 3.

(4) Summary

As should be understood from the above, the inventions defined in

claims 1 to 3, 7 to 12, and 16 to 19 are believed to have novelty and inventive step over the cited prior arts 1 to 3.

(5) Conclusion

As stated above, we believe that the inventions of claims 1 to 3, 7 to 12, and 16 to 19 have novelty and inventive steps. We wish the Examiner to re-examine these claims and to approve novelty and inventive steps of the inventions of these claims in international preliminary examination report.